Amendments to the Specification

The paragraph starting at page 1, line 10 and ending at line 16 has been amended as follows.

The present invention relates to an image processor and an image processing method for ~~deciding~~ determining formation volumes of a high-density dot and of a low-density dot for a printing medium, ~~and~~ a printing apparatus and a printing method that use the same, a program, and a storage medium that ~~stored~~ stores a computer-readable program code.

The paragraph starting at page 2, line 16 and ending at page 3, line 1 has been amended as follows.

In the printing style of the above-mentioned case (1), consumption of the light inks becomes larger as compared to the normal printing and hence a running cost becomes high, because the density in the shadow portion is intended to be deepened by ejecting the light ink in ~~a~~ an overlapping manner. In addition, the applying amount of the inks is increased to ensure the density of image, and increase of the applying amount of the inks causes the inks to overflow on a printing medium, especially when printing is done for secondary colors, tertiary colors, etc., resulting in deterioration in image quality. Moreover, because of the existence of the maximum possible applying amount of the ink, available printing mediums are limited.

The paragraph starting at page 4, line 21 and ending at page 5, line 1 has been amended as follows.

~~It is the object of the~~ The present invention ~~to~~ can provide an image processor, an image processing method, a printing apparatus, a printing method, a control program for controlling the printing apparatus, and a storage medium that ~~stored~~ stores the ~~said~~ program, which can lessen the granularity of the dots for the entire density range by properly setting formation amounts of the low-density dot and of the high-density dot, respectively.

The paragraph starting at page 7, line 26 and ending at page 8, line 2 has been amended as follows.

In a sixth aspect of the present invention, there is provided a storage medium that ~~stored~~ stores a computer-readable program code in which a control program of the fifth aspect of the present invention is stored.

The paragraph starting at page 8, line 3 and ending at line 11 has been amended as follows.

According to the present invention, the formation amounts of the low-density dot and of the high-density dot are set optimally in such a way that the maximum formation ~~amounts~~ amount of the light dot is enlarged, and hence a density range formed only with the light

ink dot expands to a wider range, while a density range in which the dark dot, whose granularity tends to become noticeable, narrows comparatively. Therefore, the granularity of the dots can be reduced for the entire density range.

The paragraph starting at page 9, line 3 and ending line 4 has been amended as follows.

Fig. 5 is an exploded perspective view of the print head of Fig. 4 as seen <u>from</u> diagonally below;

The paragraph starting at page 10, line 2 and ending at line 3 has been amended as follows.

Fig. 12 is an explanatory drawing for a case using a plurality of <u>heads similar to the</u> head shown in Fig. 11;

The paragraph starting at page 10, line 4 and ending at line 5 has been amended as follows.

Fig. 13 is an enlarged ~~cross-section~~ <u>cross-section</u> of the printing head taken along <u>section line</u> XIII-XIII ~~line~~ of Fig. 11;

The paragraph starting at page 11, line 12 and ending at line 14 has been amended as follows.

Fig. 25 is an explanatory drawing of a ~~correlationship~~ correlation between a value of an evaluation function of the granularity and subjective evaluation; and

The heading starting at page 11, line 19 has been amended as follows.

~~DETAIL~~ DETAILED DESCRIPTION OF THE PREFERRED ~~EMBODIMENT~~ EMBODIMENTS

The paragraph starting at page 12, line 5 and ending at line 9 has been amended as follows.

The ~~word~~ terms "print medium" ~~or~~ and "print sheet" include not only paper used in common printing apparatus, but also cloth, plastic films, metal plates, glass, ceramics, wood, leather or any other material that can receive ink. ~~This word~~ These terms will be also referred to as "paper".

The paragraph starting at page 15, line 20 and ending at line 25 has been amended as follows.

The ink tank for this print head cartridge H1000 consists of separate ink tanks H1900 of, for example, black, light cyan, light magenta, cyan, magenta and yellow to enable color printing with as high an image quality as a photograph. As shown in Fig. 4, these individual ink tanks are removably mounted to the print head H1001.

The paragraph starting at page 18, line 18 and ending at line 26 has been amended as follows.

Between the ~~contract~~ contact portion of the contact FPC E0011 and the carriage M4001 there is an elastic member (not shown), such as a rubber member. The elastic force of the elastic member and the pressing force of the head set lever spring combine to ensure a reliable contact between the contact portion of the contact FPC E0011 and the carriage M4001. Further, the contact FPC E0011 is connected to a carriage substrate E0013 mounted at the back of the carriage M4001 (see Fig. 7).

The paragraph starting at page 19, line 14 and ending at line 24 has been amended as follows.

As shown in the figure, a scanner holder M6001 is shaped like a box and contains an optical system and a processing circuit necessary for reading. A reading lens M6006 is provided at a portion that faces the surface of a document when the scanner M6000 is mounted on the carriage M4001. The lens M6006 focuses light reflected from the document surface onto

a reading unit inside the scanner to read the document image. An illumination lens M6005 has a light source (not shown) inside the scanner. The light emitted from the light source is radiated onto the document through the lens M6005.

The paragraph starting at page 31, line 4 and ending at line 12 has been amended as follows.

Denoted E2022 is a sensor signal processing unit which receives detection signals E1032, E1025, E1026 and E1027 output from the PG sensor E0010, the PE sensor E0007, the ASF sensor E0009 and the gap sensor E0008, respectively, and transfers ~~these~~ this sensor information to the CPU E1001 according to the mode determined by the CPU E1001. The sensor signal processing unit E2022 also outputs a sensor detection signal E2052 to a DMA controller E2021 for controlling the LF/PG motor.

The paragraph starting at page 32, line 22 and ending at line 26 has been amended as follows.

Next, ~~steps~~ step S4 waits for an event. That is, this step monitors a demand event from the external I/F, a panel key event from the user operation and an internal control event and, when any of these events occurs, executes the corresponding processing.

The paragraph starting at page 35, line 8 and ending at page 36, line 8 has been amended as follows.

In this embodiment, a printing head H with a structure as shown in Figs. 11 to 13 is used as the printing head H1001 mounted on the carriage M4001. In the printing head H of this example, a plurality of ejection ports P each capable of ejecting the ink are arranged in two lines L1, L2 (hereinafter, also referred to as "nozzle rows"). The nozzle rows L1, L2 extend in a sub scanning direction indicated by an arrow Y along which the printing medium is transferred. 128 ejection ports P (for 128 nozzles) each constituting a nozzle in each nozzle row L1 (L2) are formed at regular intervals that ~~corresponds~~ <u>correspond</u> to 600 dpi as a pitch Py. Further, the ejection ports P in the nozzle row Ll and the ejection ports P in the nozzle row L2 are shifted from each other by a half pitch (Py/2) which corresponds to 1200 dpi in the sub scanning direction indicated by the arrow Y. An arrow X indicates a main scanning direction along which the printing head H makes reciprocating motion. Then, by making these ~~totally~~ 256 ejection ports P in the two rows eject inks of the same color, the image can be printed with a dot density in the sub scanning direction ~~being~~ <u>of</u> 1200 dpi. Therefore, <u>the</u> printing resolution in the sub scanning direction becomes two times that of the case where only one nozzle row (one of the nozzle rows L1, L2) exists. Incidentally, in this example, because of a later-described reason, each dot that is formed by the ink ejected from the nozzle is controlled to have a diameter of 45 μm. A spacing that corresponds to 1200 dpi is 21.7 μm.

The paragraph starting at page 37, line 6 and ending at page 38, line 10 has been amended as follows.

Note that, in the case of this example, the resolution of the image data to be inputted into the printing apparatus from the host device is 600 ppi x 600 ppi. Here, ppi represents pixels per inch. To accommodate this resolution into a printing mode of 2400 dpi x 1200 dpi, the printing apparatus performs gradation representation for each of 4x2 printing ~~area~~ areas consisting of 4 pixels in the main scanning direction by 2 pixels in the sub scanning direction, as shown in Fig. 22B. In other words, the gradation representation is done in each unit scope (unit area) that corresponds to resolutions of 600 ppi x 600 ppi. Incidentally, the number of steps that can be represented in each unit scope is set to 9 gradations, namely gradation levels 0 to 8. Moreover, in this example, the printing apparatus is provided with 6 printing heads H, as shown in Fig. 12, which eject inks of cyan (C), magenta (M), yellow (Y), and black (K) and also inks of light cyan (Lc) and light magenta (Lm), respectively. Here, the inks of cyan (C), magenta (M), yellow (Y), and black (K) are dark inks each containing a relatively high concentration of a dye, while the inks of light cyan (Lc) and light magenta (Lm) are light inks each containing a relatively low concentration of a dye, the concentrations being 1/6 ~~times~~ those of the dark inks. Thus, different inks are ejected from the respective printing heads, each consisting of the two nozzle rows L1, L2, whereby a color image is printed. When a printing mode of 1200 dpi x 1200 dpi is accommodated, the gradation representation is performed for each 2x2 printing area consisting of 2 pixels in the main scanning direction by 2 pixels in the sub scanning direction (a unit scope that corresponds to resolutions of 600 ppi x 600 ppi), as shown in Fig. 22A.

The paragraph starting at page 39, line 13 and ending at page 40, line 1 has been amended as follows.

Note that how to define the applying amount is not limited to this example, and it may be defined as follows. That is, the applying amount of the case where the dots necessary and sufficient to cover the unit scope that corresponds to resolutions of 600 dpi x 600 dpi are formed, as shown in Fig. 22A, may be defined as ~~a~~ an applying amount of 100 %. Concretely, the applying amount of the case when 4 dots are formed in the unit scope that corresponds to resolutions of 600 dpi x 600 dpi as in Fig. 22A is defined as 100 %; the applying amount of the case when 8 dots are formed in the unit scope that corresponds to resolutions of 600 dpi x 600 dpi as in Fig. 22B is defined as 200 %. Therefore, when 5 dots are formed in a unit scope that corresponds to resolutions of 600 dpi x 600 dpi, the applying amount becomes 125 %; when 7 dots are formed in ~~the~~ said unit scope, the applying amount becomes 175 %.

The paragraph starting at page 40, line 2 and ending at line 14 has been amended as follows.

Thus, in this description, with ~~regarding~~ regard to the "applying amount", when a certain number of the dots necessary to cover a specified unit scope (unit area), such as a unit scope that corresponds to resolutions of 1200 dpi x 1200 dpi and a unit scope that corresponds to resolutions of 600 dpi x 600 dpi, are formed in ~~the~~ said unit scope, the applying amount equivalent to that number of the dots (N) is defined as ~~a~~ an applying amount of 100 %.

Therefore, when 2N dots are formed in a specified unit scope (unit area) previously specified, the applying amount becomes 200 %; when 1.75N dots are formed in a specified unit scope (unit area) previously specified, the applying amount becomes 175 %.

The paragraph starting at page 40, line 15 and ending at line 27 has been amended as follows.

As shown in Fig. 14, regarding the dark ink, for ink applying amounts from 0 to 100 %, the density goes up almost in proportion. However, when the applying amount exceeds 125 %, the density hardly goes up at all. Further, when the applying amount increases up to 200 % or beyond, no density increment is observed but ~~inversely~~ inverse density decrement is observed and deterioration in the image quality due to overflow of the ink occurs. Therefore, it is found that, regarding the total applying amount of the ink in printing the secondary colors, the tertiary colors, and more, even if the ink is forcibly ejected for applying to a degree equal to 125 % or more, little merit can be obtained in terms of the image quality.

The paragraph starting at page 41, line 1 and ending at line 12 has been amended as follows.

On the other hand, regarding the light ink, for the ink applying amounts from 0 to 200 %, the density goes up effectively almost in proportion. Further, when the applying amount is increased up to 300 %, the density itself hardly goes up at all, and in the ~~worse~~ worst

case, the ink may overflow from the printing medium to effect ~~the~~ deterioration in the image quality. In consideration of this, it can be said ~~that~~ then that usage of the light ink brings about the density enhancement and excellent gradation characteristics as long as the light ink is used in a range from 0 % to just below 300 %, which exceeds 200 %, as compared to the case with the light ink being used at 100 %.

The paragraph starting at page 43, line 21 and ending at page 44, line 10 has been amended as follows.

Thus, in this embodiment, when deciding the formation volumes of the light dot (low-density dot) and of the dark dot (high-density dot) for a specified unit area, the LUT as shown in Fig. 16 is used. The LUT specifies that for the light ink whose density increases linearly at least up to 200 %, the maximum applying amount is set to 200 % (the first peak), and for the dark ink whose density increases linearly up to ~~a~~ an applying amount of 100 %, the maximum applying amount is set to 100 % (the second peak). With this setting, a width of the gradation levels (density levels) where the gradation is formed only with the light ink, whose granularity is hard to notice, can be widened, while a width of the gradation levels (density levels) where the gradation is formed with the dark ink, whose granularity is relatively easy to notice, can be narrowed; therefore, the granularity of an image as a whole can be reduced.

The paragraph starting at page 49, line 6 and ending at line 15 has been amended as follows.

In the image processing portion 230 configured as such, first, 8-bit data of each of R, G, and B colors inputted from an external host apparatus are converted into 8-bit data of R', G' , and B' colors by a three-dimensional LUT in the color space conversion processing portion 211. This processing is also ~~refereed~~ referred to as pre-stage color processing where processing of conversion for compensating a difference between a color space of the input image and a reproduced color space of an output device is performed.

The paragraph starting at page 49, line 16 and ending at page 50, line 14 has been amended as follows.

Next, the 8-bit data of R', G', and B' colors that have undergone the pre-stage color processing are converted into 8-bit data of C, M, Y, and K colors by the three-dimensional LUT of the color conversion portion 212. This processing is also ~~refereed~~ referred to as post color processing where colors of the RGB system of the input system are converted into colors of the CMYK system of an output system. Further, data of each of C (cyan) and M (magenta) is separated into data for the dark ink and data for the light ink, respectively. In this separation, the data for C (dark cyan) and the data for Lc (light cyan) are separated so that ink applying amounts ~~for~~ of the dark ink and of the light ink satisfy the relation of Fig. 16 or Fig. 17 described above. Similarly, data for M (dark magenta) and data for Lm (light magenta) are separated so that ink applying amounts ~~for~~ of the dark ink and of the light ink satisfy the relation of Fig. 16 or Fig. 17 described above. Specifically, the LUTs of Fig. 16 and Fig. 17 determine the dark and light ink applying amounts for each specified unit area (unit scope that corresponds to resolutions of 600

dpi x 600 dpi) consisting of 8 pixels (4x2) in Fig. 22B that was previously determined. Therefore, each of the horizontal axes of the LUTs of Fig. 16 and Fig. 17 denotes a value obtained by averaging input gradation levels for the 8 pixels (4x2) contained in the specified unit area.

The paragraph starting at page 56, line 18 and ending at page 57, line 11 has been amended as follows.

Next, correlation between the granularity evaluation value (G) and the testee's test results was obtained. A printer used in the measurement is a BJF-850 printer manufactured by Canon (6-color, dark-and-light ink-jet printer, resolution 1200 dpi x 1200 dpi, dot diameter 40 μm), and a drum scanner is ~~ScanMaster4500~~ a ScanMaster 4500, manufactured by Howtek. In this measurement, a uniform density patch (gray scale 50%) was outputted by the printer using K (black) ink and its output image was read by the drum scanner whose resolution was set to 1000 dpi. An input image by the ~~dram~~ drum scanner is divided into ~~1024x1024~~ 1024 x 1024 (pixels), which are estimated using the granularity estimation function. Fig. 25 is the evaluation result.

The paragraph starting at page 58, line 5 and ending at line 16 has been amended as follows.

Using the granularity evaluation function, the ink density and the dot diameter are investigated in search of optimum values thereof that achieve a small granularity value equal

to 0.4 or less for the entire density range. As a result, it was found that in a 6-color, dark-and-light ink-jet printer such as in this example, by setting the dot diameter to 30 ~~µm(with a~~ µm (with an ejecting amount of 2 pl; note that a blotting ratio is set to about 2.0) and setting an ink dilution ratio of the light ink to 1/3 ~~times~~ that of the dark ink, the granularity can be diminished for the entire density range even with a maximum applying amount of the light ink being 100 %.

The paragraph starting at page 60, line 19 and ending at line 25 has been amended as follows.

Needless to say, the present invention includes not only the case where the computer executes the read program code, whereby the ~~above-motioned~~ above-mentioned function of the embodiment is achieved, but also a case where an OS (operating system) running on a computer performs part of or all of actual processing according to instructions of the program code.

The paragraph starting at page 60, line 26 and ending at page 61, line 8 has been amended as follows.

Further, needless to say, the present invention includes a case where the program code read from the storage medium is written into memory provided in a function enhancement board being inserted into the computer, or into memory provided in a function enhancement unit connected ~~ton~~ to the computer, and subsequently a CPU, etc., provided in the

function enhancement board or the function enhancement unit performs part of or all of actual processing, and the function of the above-mentioned embodiment is achieved through the processing.

The paragraph starting at page 63, line 11 and ending at line 16 has been amended as follows.

The present invention can be also applied to a so-called full-line type printing head whose length equals the maximum length across a printing medium. Such a printing head may ~~consists~~ consist of a plurality of printing heads combined together, or one integrally arranged printing head.